Varietal and Geographical difference in Anatomy and Morphology of Bamboo seeds (*Bambusaarundinacea* Retz and *Dentrocalamusstrictus* Ness)

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Abstract

Bamboo farming gives rural residents the chance to engage in activities that generate cash, and it also provides employment opportunities for small and medium-sized businesses and those who participate in the industry. The tribal people are well-versed in the practical applications of these bamboo resources in their daily lives. On the other hand, little is known about the applications for bamboo seeds. The purpose of this research is to evaluate the physical features, seed structure, and milling qualities of two bamboo types that are grown in Tamil Nadu (Ba-T and Ds-T) and Kerala (Ba-T and Ds-K): *Bambusa arundinacea* Retz–Ba and *Dentrocalamus strictus* Ness - Ds. *Arundinacea Bambusa Dentrocalamus strictus* Ness seeds are elliptical in shape, broad, and sharply pointed at the opposite end, whereas Retz seeds are elongated, cylindrical, and somewhat conical at the ends. Regardless of species or location, seeds had a dense portion of starch, and transverse slice examination showed the presence of the seed coat, embryo, and hilum. The range of the milling recovery was 87 % to 93 %, with BA-K having a notably high percentage of 92.67 %. Regardless of where they grew, both types showed a significant variation in every parameter that was measured.

Key words: variety, milling features, anatomy, physical attributes, and geographic location of bamboo seeds

Introduction

One of the earth's most valuable plant resources is bamboo. Since the dawn of human civilization, it has been essential to the survival of nearly two billion people who live in the tropical and subtropical regions of Asia, Latin America, and Africa. The traditional applications of bamboo vary from person to person and from place to location. Indigenous communities have utilized bamboo for food, fuel, shelter, and housing from the beginning of time (Sastry 2003; Panigrahi 2003; Panigrahi et al. 2003). Like corn, sugar cane, and other grasses, bamboos belong to the Graminae (Poaceae) family (Khare 2007). Normally new bamboos grow up from bamboo shoot at the roots. Changes in soil nutrition or humidity make it harder for plants to

grow and cause them to blossom. The fruit that the flower bears after it blossoms is known to the Chinese as "BAMBOO RICE." In the Southern Western Ghats of the Kanyakumari district, in the Pacific area of Asia, a total of 26 kinds of bamboo are utilized for food purposes. Two bamboo species, *Bambusa arundinacea Retz* and *Dendrocalamus strictus* Nees, flourish gregariously in this region due to its geographic location, stable geological history, favorable agroclimate, heavy rainfall, and good soil conditions (Joseph 1959; Savur, 2003). The indigenous people possess extensive knowledge regarding the practical applications of these bamboo resources in their daily lives (Pongen and Salam 2008). Many studies on bamboo seed and its characteristics have recently been started in an effort to understand the variables influencing its quality and to take advantage of the potential applications of bamboo seed in other processed food products. On the other hand, no research has examined the morphology and anatomy of bamboo seeds. Therefore, in order to evaluate the differences based on variety and geography, the anatomy, morphological traits, and milling properties of specific bamboo seed types grown in Tamil Nadu and Kerala were evaluated in this study.

Materials and Methods

Bamboo Seeds

The Department of Forest Service in Salem provided the bamboo seed kinds of *Bambusa arundinacea* Retz and *Dentrocalamus strictus* Ness, which are produced in Tamil Nadu and Kerala. The seeds were washed and manually winnowed to remove dust and other foreign materials before being utilized for additional examination. Prof. P. Jayaraman, Director of the Institute of Herbal Botany at the Plant Anatomy Research Center in Chennai, Tamil Nadu, verified the authenticity of the chosen bamboo paddy types, which were subsequently tagged for this study.

Sample Code	Name of the Sample
Ba-T	*Bambusa arundinacea* grown in Tamil Nadu
Ba-K	*Bambusa arundinacea* grown in Kerala
Ds-T	*Dentrocalamus strictus* grown in Tamil Nadu
Ds-K	*Dentrocalamus strictus* grown in Kerala

Features of the Anatomy

Using a polarized light microscope, the anatomical structure of bamboo paddy grown in Tamil Nadu and Kerala, specifically *Bambusa arundinacea* Retz and *Dentrocalamus stricus* Ness, was examined.

Collection of Specimens

The bamboo seed specimens that were in good condition were preserved in FAA (formalin, 5 ml; acetic acid, 5 ml; and 70% ethanol, 90 ml). The specimens were dehydrated using a graded series of tertiary-butyl alcohol following a 24-hour fixing period, following the regimen provided by (Sass 1940). Paraffin wax, which has a melting point of 58 to 60 degrees Celsius, was added gradually to the specimens until the TBA solution reached saturation. The samples were poured into blocks of paraffin.

Sectioning

The paraffin embedded specimens were sectioned with the help of Rotary Microtome. The thickness of the sections was 10-12 µm. Dewaxing of the sections was by customary procedure (Johansen 1940). The sections were stained with toluidine blue as per the method published by (O'Berien

et al. 1964). Since toluidine blue is a polychromatic stain, the staining results were remarkably good; and some cytochemical reactions were also obtained. The dye rendered pink colour to the cellulose or walls, dark green to suberin, violet to the mucilage, blue to the protein bodies etc. Wherever necessary sections also stained with Safranin and Fast–green and IKI (Iodine Potassium Iodide) staining solution (for Starch).

Following staining, powdered components of various portions were cleaned with NaOH and mounted in glycerin medium. Various cell constituents were examined and quantified (Johansen 1940).

Photomicrographs

Where needed, a microscopic description of the tissues was added. Nikon Lab Photo 2 Microscopy Unit captured images at various magnifications. In bright field, regular observations were conducted. Polarized light was used to analyze crystals, starch grains, and lignified cells (Metcalfe and Chalk 1950). These structures seem bright against a black background because they have the property of being birefringent under polarized light (Metcalfe and Chalk 1950). Scale bars represented the figures' magnifications. The Standard Anatomy books' descriptions of the anatomical features were followed (Easu 1979).

Morphological Characteristics

Based on variety and region, morphological characteristics—that is, physical attributes and milling characteristics—were examined and distinguished.

Thousand Paddy Weight

The mass of a thousand bamboo paddy was calculated by randomly selecting 100 paddy, weighing it in triplicate on a digital balance, and multiplying the result by ten (AACC 2009). **Length, Breadth and Thickness**

A digital vernier caliper was used to measure the three primary dimensions of the entire bamboo paddy, namely length (L), width (B), and

thickness (T), with an accuracy of 0.02 mm. The results are expressed in millimeters (mm) (AACC 2009).

Equivalent Diameter

The following relationship was used to compute the equivalent diameter of a full bamboo paddy; the results are expressed in millimeters (mm) (Mohesnin 1970).

where

Dm is the equivalent diameter or geometric mean diameter (mm) and Dm= (LBT) 1/3

B = Breadth (mm) and L = Length (mm)

T is the thickness (mm).2. Sphericity

The bamboo paddy's sphericity was ascertained using the following equation: (φ) = (LBT)1/3/L 14.

where

L is the length (mm).

B is for breadth in millimeters.

T is the thickness (mm).

Classification of paddy

The chosen bamboo paddy was categorized using the length-to-width ratio as per Vanangamudi et al. (1987).

Size category	**Length in mm**	**Width category**	**Width in mm**
Short	Below 7.5 mm	Slender	Below 2 mm
Medium	7.5-9.0 mm	Semi-long	2.0-2.4 mm
Long	9.0 -10.0 mm	Semi spherical	2.4-3.0 mm
Very long	Above 10.0	Spherical	Above 3.0 mm

	mm		

Milling Characteristics

Since milling is the procedure that turns the rice grain into a shape that is fit for human consumption, it must be done carefully to avoid breaking the kernel and enhance recovery. To make white rice that is more aesthetically pleasing, brown rice is further ground. Paddy undergoes the initial milling process, which involves dehusking and the removal of bran layers, following harvest and drying (www.rkmp.co.in 2013).

Rice mills operate on a daily basis, including measuring the quality of the milled rice and paddy. Systematic rice mill testing can also provide useful information on the effectiveness of rice milling as well as challenges and solutions to improve milling yield and milled rice quality (IRRI 2008).

Dehusking

At Sri Vinayaka Rice Mill in Salem District, Tamil Nadu, India, the Bambusa arundinacea paddy (Ba-T and Ba-K) was dehulled using a Rubber Roller Dehusker cum Polisher (Satake Corporation, Tokyo, Japan). The Ds-T and Ds-K varieties of Dentrocalamus strictus have an extremely hard outer coat that was removed by hand pounding with a wooden pestle and mortar. To investigate the milling properties, the husk, cracked, and unpolished kernel of both kinds (Ba-T, Ba-K, Ds-T, and Ds-K) of diverse geographical origins were gathered.**Characterization of Milling Fractions**

By examining the milling recovery(%), dockage in milled broken(%), head kernel(%), form of dehusked kernel and cracked kernel(%), and head kernel(%), the bamboo paddy's milling fractions were determined (IRRI 2008)**.**

Milling Recovery (%)

The bamboo paddy that had been dehulled was ground using the Abrasive Whitener. By dividing the weight of recovered milled rice by the weight of the paddy, the triple value of milling recovery was calculated.

$$\text{Milling Recovery} = \frac{\text{Wt.of Dock-age}}{\text{Wt. of milled paddy}} \times 100$$

Dockage in Milled Rice (%)

As a proportion of dockage, the foreign stuff found in 1000 g of milled paddy was separated. Three times over, the percentage of dockage in milled paddy was calculated and found to be

$$\text{Dockage in milled rice} = \frac{\text{Wt.of Dock-age}}{\text{Wt. of milled paddy}} \times 100$$

Broken Kernel (%) and Head Kernel (%)

The broken kernel was isolated from the complete kernel using the Grain Grader. Three copies of the head rice and broken percentage were completed, and the result was calculated as

$$\text{Head rice (\%)} = \frac{\text{Wt.of Dock-age}}{\text{Wt. of milled paddy}} \times 100$$

$$\text{Broken (\%)} = \frac{\text{Wt.of Dock-age}}{\text{Wt. of milled paddy}} \times 100$$

Kernel Shape

Ten heads of rice were measured for length and width in millimeters. The length to width ratio was used to determine the milled rice's form.

$$\text{L/W ratio} = \frac{\text{Lengtho frice (mm)}}{\text{Widtho frice (mm)}}$$

Cracked grain (%)

The percentage of cracked grain was calculated by counting the number of cracked grains in 100 dehusked grains using the Paddy Crack Detector.

$$\text{Creaked grains (\%)} = \frac{\text{Number of craked grains}}{\text{100 dehusked grain}} \times 100$$

Results and Discussion

Anatomical Characteristics

A particularly useful component of taxonomy is identification. Many economically significant seeds can be identified down to the specific and even varietal levels based on surface traits. particularly minute seed fragments can also be identified based on histological structure (Vaughan 1968).

Bambusa arundinacea Retz. Seeds

The seeds are cylindrical, long, and have a little concavity at the ends. A quite lengthy and profound hilum extends down the middle portion of the seed. The groove on the hilum is wide (Fig. 1). The seed is semicircular on the outside of the hilum (Fig. 2). The seed has a thickness of 2.2 mm in the middle vertical area and 1.2 mm in the middle median part.The seed consists of a thin continuous seed coat includes unistratose; two layers of small thick walled outer seed coat.

Around the hilum, the outer seed coat thickens somewhat and consists of two or three cell layers (Fig. 3). There is one more seed coat layer inside. In the hilar region, the seed coat is likewise noticeably thicker and has numerous layers (Fig. 4).

A layer of parenchyma cells, which are single-layered and extended at right angles to the hilum, is found inside the seed coat. In the other area, the parenchyma cells have rich cell contents and are elongated, parallel to the seed coat, and two to three layers thick (Fig. 5).

The seed's endosperm is made up of cellular, polygonal, elongated, thin-walled cells. Their starch granules are thick (Fig. 6). According to (Belitz) and (Grosch and Schieberle 2020), the endosperm, which is made up of the starchy endosperm and the aleurone layer, is enclosed by fruit and

seed coats (bran) that surround the germ. A similar observation was made for the Bambusa arundinacea Retz seed, indicating that it may fall under the category of cereal grains.

Dentrocalamus strictus Ness Seeds

The seeds have an oval form, a wide breadth, and an elongated, sharply pointed end on the opposite end (Fig. 7). They are light brown in color. The embryo is encased in the membrane seed coat of the embergonal end. In cross section, the seed coat's exterior features a deeply defined hilar region and a slightly elevated top region. According to Figure 8, the thickness of the seed is 1.3 mm in the vertical hilar region and 2.7 mm in the horizontal zone. The seed has a thick layer of endosperm and a thin seed coat.The 40 mm thick, sclerotic seed coat encircles the entire seed. It is typically composed of compact, columnar macrosclerosis with a palisade-like texture and cuticle. There are roughly three layers of parenchyma zone located inside the sclerotic seed coat. These cells (Figs. 9 and 11) are round and have a rich cell composition. The thicker seed coat on the elevated upper portion of the seed has one or two layers of thick-walled parenchyma cells and numerous layers of angular sclerosis (Fig. 10). The walls of the endosperm cells are thin, round, and broad. The cells take on a polygonal form and are compact. The entire cell is filled with thick starch grains (Figs. 13. and 14.).

Morphological Characteristics

Physical Properties

It is essential to look into the physical qualities of rice grains in order to try post harvest processing of various cultivars with quality characteristics. Understanding the physical and engineering characteristics of grain materials is helpful in developing machinery that is suitable for process

operations such as milling, drying, heating, cooling, and sorting, as well as in solving issues that arise from these processes (Souci 2008; Sahay and Singh 1999; Correa et al. 2007). Table 1 shows the variations in the thousand grain weight, length, width, thickness, equivalent diameter, L:W ratio, and sphericity of bamboo paddy that were observed between different geographical locations.

There were significant differences ($p<0.05$) in all determined physical parameters between varieties, although not geographically; Ds-T and Ds-K had significantly higher values than Ba-T and Ba-K variety. In particular, rice varieties ofada 3 and 4 exhibited a thousand seed weight of 24.0 g, which was reported by (Liu et al. 2009; Ogut 1998; Jha 1999). These rice varieties showed similar values of thousand grain weight to Ds-T and Ds-K. In Tirunelveli, Madurai, and Virudhunagar rice varieties, (Simonyan et al. 2007) discovered a level of 1000 grain weight that was similar to Ba-T and Ba-K; 14.5 g in CO 31 and 18.5 g in Ambai 16, 14.0 g in Sonam and 18.2 g in CR 1009, 15.7 g in TR 1, and 17.9 g in CR 1, respectively.
Important characteristics for evaluating grain quality are the L/B ratio and kernel shape (Kanchana et al. 2012). Important traits linked to good crop stand, good grain production, and seedling vigor and quality are seed size and weight (density) (Rita and Sarawgi 2008 Tseng et al. 1962; Kamil 1975) That being said, research has revealed that grain weight varies significantly between cultivars, within individual panicles, and even within a cultivar (Arain et al. 1990; Venkateswarla et al. 1986; Vergara et al. 1990). Hence, the nature of the plant could account for the notable differences in physical characteristics across the researched kinds of bamboo seeds.

The length of the bamboo paddy variety was found to support the identical length ratio values obtained in Tarom rice paddy (minimum 1.81 – maximum 2.85 mm) and Khazar paddy (minimum 1.95 – maximum 2.92 mm) (Teng et al. 1993). The Tarom variety, which had a mean value of 1.79 mm as investigated by Bagheri et al. (2013), and the Indian paddy variety,

SKAU-345, which had a mean value of 2.66 mm as studied by Bagheri et al. (2013), were comparable with the breadth values of Ba-T and Ba-K.

Codex standard (198-1995) (Mir et al., 2013) states that rice with a length/width ratio of 2.0 or less is classified as short grain rice; the bamboo paddy types Ba-T, Ba-K, Ds-T, and Ds-K were all deemed to be short and slender grain varieties. The Ba-T and Ba-K bamboo seeds were short (length below 7.0 mm) and thin (width below 2.0 mm), whereas the Ds-T and Ds-K bamboo seeds were short (length below 7.0 mm) and semi-spherical (width below 2.4 – 3.0 mm), according to the categorization proposed by Vanangamudi et al. (1987).When compared to Ba-T and Ba-K, the sphericity was higher in Ds-T and Ds-K. The variation in varietals could be the cause.

Milling Characteristics

When comparing the two bamboo seed varieties, Ba-K and Ba-T had a considerably ($p<0.05$) higher milling recovery than Ds-T and Ds-K (Table 2). Ba-T and Ba-K differed significantly from one another geographically, while Ds-T and Ds-K did not show this difference. A excellent rice variety should have a head rice out turn of at least 70%, according to Mir et al. (2013). The rice varieties Lal Beruin (91%) and Kathali Beruin (90%) showed comparable levels of milling recovery. On the basis of this, every bamboo seed analyzed indicated good quality with a milling recovery of more than 190%.

When compared to Ba-T and Ba-K, the husk percentage in Ds-T and Ds-K was much higher; nevertheless, there was no significant difference between the two regions. According to (Vanangamudi et al. 1987 and Dipti et al. 2003), agronomic practices, variety, and environmental factors all affect how much bran is present in rice kernels. According to Sarker and Miyahara (1984), the presence of additional immature grains in rice reduces milling output and increases the formation of husk, which can account for 30–40% of the grain weight. The maturity of the paddy was indicated by the

husk percentage, which ranged from 5 to 10% in both varieties of bamboo paddy.

In comparison to Ba-T, Ba-K, and Ds-K, Ds-T showed noticeably more broken grains during milling ($p>0.05$) based on the broken grains of bamboo paddy. According to (Kanchana et al., 2012), one cereal crop that is eaten whole, milled, and broken is rice. The desired qualities may differ from nation to nation as well as from one ethnic group or geographic area to another. Consumers want their rice to be white, translucent, have a low percentage of broken or damaged grains, and contain little foreign objects. According to (Ruiten van 1985), when it comes to the milled rice choice, untreated rice has 13% broken grains and parboiled rice has 3% broken grains, both of which are acceptable to the local consumers.

The low proportion of broken grains and high milling recovery of bamboo seeds indicated that this cereal had the desired qualities for human consumption, comparable to those of rice.

When compared to other bamboo paddy under study, Ba-T had the greatest percentage of broken grain—significantly higher at $p<0.05$. It is widely acknowledged that a number of factors are likely to contribute to rice breaking during milling. Since delayed harvesting and threshing, one of the variables is known to be kernel cracking or checking (Sarker and Miyahara 1984; IRRI 2013; Roy 2003). Chalk and immature kernels are also thought to break somewhat easily. In addition, shape and hardness of the kernels seem to be important determinants, since long grains and soft kinds are generally thought to be more prone to breaking than short grains and hard variants (Rhind, 1962; Craufurd, 1962).

Dockage is any material other than rough rice that is easily extracted from the rough rice; this is often accomplished by using the proper sieves and cleaning tools. Rough rice kernels that are undeveloped, shriveled, and small fragments that are either poorly separated from the dockage or

exhibit poor recovery after rescreening or recleaning may also be included (Angladette 1963). Out of all the bamboo paddies investigated, the dockage in milling is less than 2 percent.

Conclusion

Arundinacea Bambusa, Dentrocalamus strictus Ness and Retz seeds differed significantly in all variety-related factors examined, although not in terms of geography. Bamboo seeds, like wheat, rice, maize, barley, oats, rye, millet, and sorghum, are major sources of energy due to the presence of endosperm in the seed and dense starch grains that cover the entire cell of the reflected endosperm. They are also said to be the ideal cereal to replace rice. In addition to being a significant component of diet, these seeds are also rich in a variety of nutrients that support good health. They are also regarded as a functional food, and research has shown that the planting, harvesting, and processing of bamboo products—particularly bamboo seeds—have a positive economic impact on various geographic regions.

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Data Availability Not applicable

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